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PREDICTION OF TARGET TRAVEL DURING MISSILE TIME OF FLIGHT: A COMPUTER SIMULATION

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An experiment was conducted at the US Army Human Engineering Laboratory command/control simulator facility to measure an antitank guided missile (ATGM) gunners ability to predict future target position.

Fifteen randomly selected ATGM gunners, MOS 11B, were tested.

In two computer test programs, a moving tank and background were simulated on a CRT display. In the first program, subjects attempted to fire so that the ATGM would impact the target just as it reached a specified position on the display. Target distance, target speed, and time available to next page

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estimate target speed were varied. In the second program, the subject had to decide if a gap between two covered areas was wide enough for a missile to be fired successfully. Functional relationships between gunners' ability to predict target position, and target distance, speed, and time available were determined for the first part of the experiment. Functional relationships between gunners' ability to make correct decisions, and target distance, speed and gap size vere determined for the second part of the experiment.

It was concluded that the gunners' ability to predict target future travel and decide whether or not to fire is limited, but increases with practice.

Although both experiments measured subjects' ability to predict future target travel, results from the first computer simulation cannot be used to predict performance in the other computer simulation. This indicates that subjects used different strategies to predict future target travel when a very short time was available as opposed to when much longer time was available.

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PREDICTION OF TARGET TRAVEL DURING MISSILE TIME OF FLIGHT: A COMPUTER SIMULATION

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PREDICTION OF TARGET TRAVEL DURING MISSILE TIME OF FLIGHT: A COMPUTER SIMULATION

INTRODUCTION

An antitank guided missile's (ATGM) time of flight is such that before the missile reaches the intended target, the target may disappear partially or fully behind some terrain feature (e.g., a terrain fold, hill or woods). To avoid this possibility, the gunner must decide if and when he should fire at a target based on his estimate of the target's angular velocity (i.e., distance and speed), his knowledge of missile time of flight, and the perceived angular size of the gap the target must cross to reach concealment. There are four possible outcomes of the gunner's decision:

1. The gunner chooses to fire and the gap is wide enough--a correct decision resulting in a hit.

2. The gunner chooses to fire and the gap is not wide enough--an incorrect decision resulting in a miss.

3. The gunner does not fire and the gap is wide enough—an incorrect decision.

4. The gunner does not fire and the gap is not wide enough—a correct decision.

Whereas for the second category the gunner wastes one missile and discloses his position, for the third category he merely misses an opportunity to hit a target. The consequences of this decision can only be estimated subjectively but are probably not as severe as those of a miss.

To aid the soldier in making his decision to fire, some guidance is given in the US Army DRAGON manuals (1). Specifically, it is stated that all gaps between areas of target concealment be classified as "fire gaps" or "no-fire gaps" assuming a maximum target speed of 10 meters per second (22 mph). Although the classification procedure (1, pp 63-64) is overly complex, it is easily simplified as shown in Appendix B.

Current force-on-force computer models (e.g., AMSWAG) assume the gunner will fire if line of sight (LOS) exists between him and the target, and does not account for the time the target is available. In other words, they do not account for the probability that the gunner does not fire given LOS to the target.

Information on the gunner's decision making capability when given a target is needed not only to upg[illegible]e computer models but to assess more realistically product improvement programs for DRAGON and TOW. This type of information is also applicable to systems employing a ground laser locator designator (GLLD), such as COPPERHEAD.

Thus, there is a need to establish the functional relationship between target movement and gap size, and the gunners' decision whether or not to fire. Little information on this subject appears in the literature. Unpublished results of one field experiment (3) provide some information on gap sizes for which all gunners will choose to fire and gap sizes for which no gunner will choose to fire.

The US Army Human Engineering Laboratory (HEL) is currently planning field experiments to address this data gap. In order to provide guidance in defining the test parameters, a two-part experiment was conducted using computer simulated pictures of tank targets. It is believed that the results of the experiment can help determine what parameter values should be used in a field experiment.

PURPOSE

The purpose of the first test phase was to measure the gunner's ability to predict a target's future position when given a relatively long time to estimate the target's speed.

The purpose of the second test phase was to determine the gunner's ability to decide whether or not to fire at a target crossing a gap between two covered areas.

METHOD

Subjects

The subjects were 15 randomly selected US Army DRAGON gunners, MOS 11B. Their ages ranged from 18 to 27 years, and time in the Army ranged from 8 to 47 months. Although their previous DRAGON gunnery scores could not be obtained, the subjects rated their performance as: Expert, seven subjects; first class gunner, five subjects; second class gunner, one subject. Two subjects could not define their DRAGON rating. Additional information on subjects is given in Appendix A.

Test Facility

The experiment was conducted in the HEL Command/Control Simulator Facility (which is described in [4]). Subsystems of the facility used for this experiment were primarily the IDIIOM (CRT) calligraphic display and the Varian 620 f/100 computer.

Computer Programs

Two different computer programs called "Shoot" and "Gap" were used to present to a subject a simulated moving tank and other visual information on a CRT.

Test variables used in both programs are described and defined in Table 1. Reference 3 was used to establish the minimum and maximum gap widths for testing. The levels of the independent variables, (timeofflight[TF], time to decide [TD], etc.) for each run were selected randomly without replacement from the 24 possible combinations listed in Tables 1C and 2C (Appendix C).

TABLE 1

Test Variables

Variable	Type	Control, Definition
Target run parameters (Target speed, gap width, time of flight, target range, time to practice, time to decide, etc.)	Independent	The parameter combination was picked by the computer. All combinations were used once in each session. Exact parameter values were picked within certain constraints (see Appendix C).
Relative gap size	Independent	A gap with a relative size of unity has an absolute size equal to time of flight x target speed.
Error in Shoot runs	Dependent	Error is measured in mils between the target center and the goal post. If the target stops early, the error is negative.
Decision ability in Gap experiment (to fire or not)	Dependent	A correct decision is a firing of a missile when this can be done successfully, or not firing a missile when it would be wasted. If at least one-half of the target was exposed at the end of TF, a correct decision was scored. Percent correct decisions is the measure used.
Decision time in Gap experiment	Dependent	Time from the appearance of a target's leading edge to fire decision. This value can be recorded only in the runs where the subject fires. The value can be negative, if the subject fires before the target center appears.
Practice level	Controlled	Practice runs given at the start of each trial.
Viewing distance	Controlled	Headrest
Physical fatigue	Controlled	Subjects rested for at least 30 minutes before arriving at the computer room.
Stress	Controlled	Subjects were told that a small gift would be given to the best "player" and that results would not be reported to their commanders.

In the Shoot program the simulated target area had a horizon as shown in Figure 1. When the gunner pressed a key, a side-on tank which moved at a constant velocity along a dotted ground track and numerals which indicated simulated missile time of flight (TF) appeared in the target area (Figure 2).

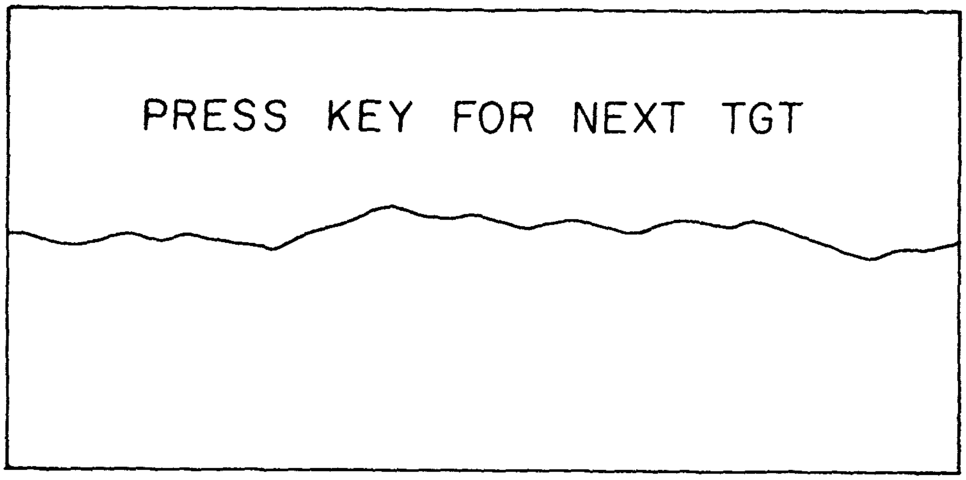


Figure 1. Shoot program, initial display.

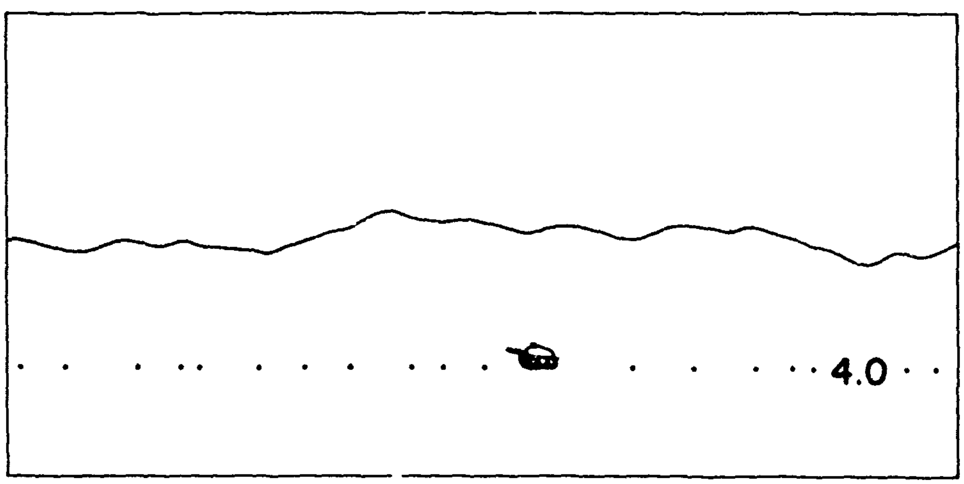


Figure 2. Shoot program display during "time to practice."

The subject was given a predetermine time, TP, in which to view the target and estimate its speed. At the end of TP, a goal post, which was four times the height of the tank, appeared ahead of the tank (Figure 3).

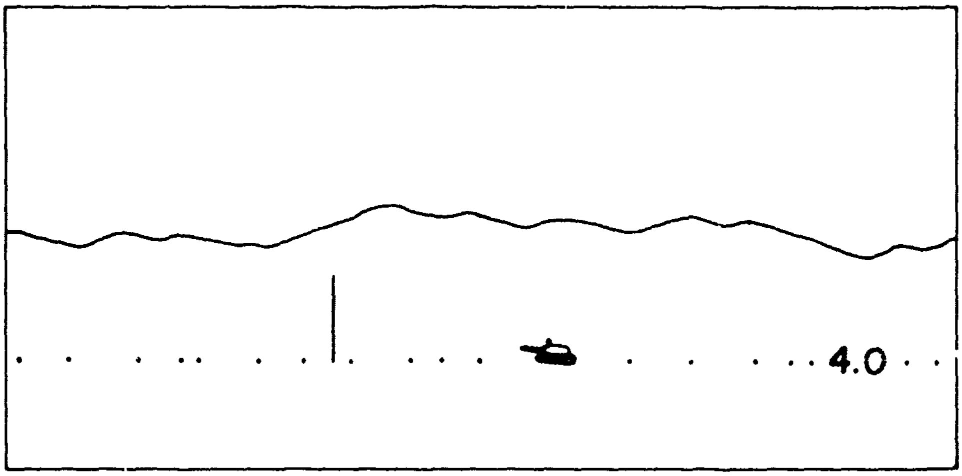


Figure 3. Shoot program display during (and after) "time to decide."

The object was to decide when to fire so that the target center was aligned with the goal post TF seconds after firing. The ideal time to fire was TD seconds after the appearance of the goal post.

TF seconds after the gunner fired, the target stopped for 2 seconds, so as to provide the subject with feedback about his performance. Then, the target's position was recorded and the display once again showed the picture in Figure 1. The missile was assumed to have a constant velocity of 100 m/s, so TF was proportional to the simulated target range. Thus, a simulated target distance of 500 meters meant that the time of flight was 5 seconds.

In the second program, GAP, the display consisted of two covered areas and a track line shown in Figure 4. When the subject pressed a key, TF was displayed and followed a few seconds later by the side-on, constant velocity target.

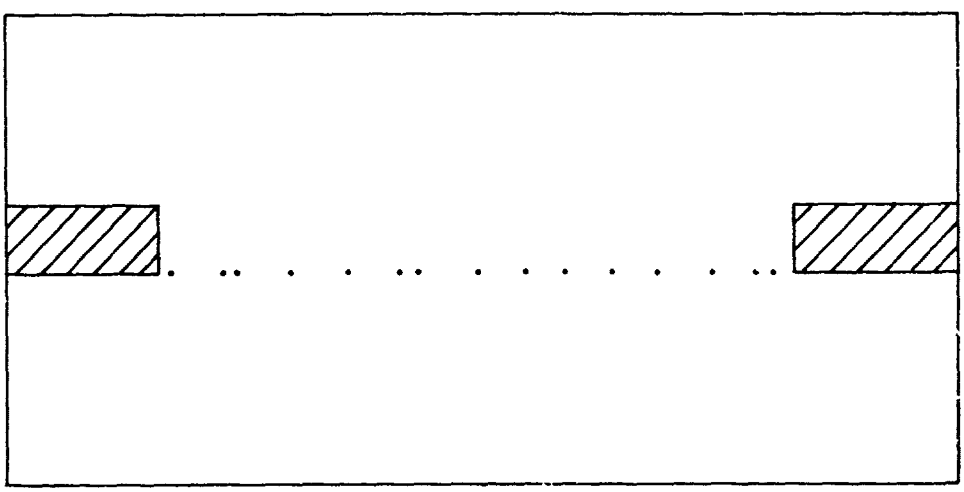


Figure 4. Gap program display showing covered areas and dot track.

The object was for the gunner to decide whether the gap was wide enough for a missile to be fired successfully; i.e., hit the target before more than half of it was hidden by the covered area. Figure 5 shows the target part-way through the run.

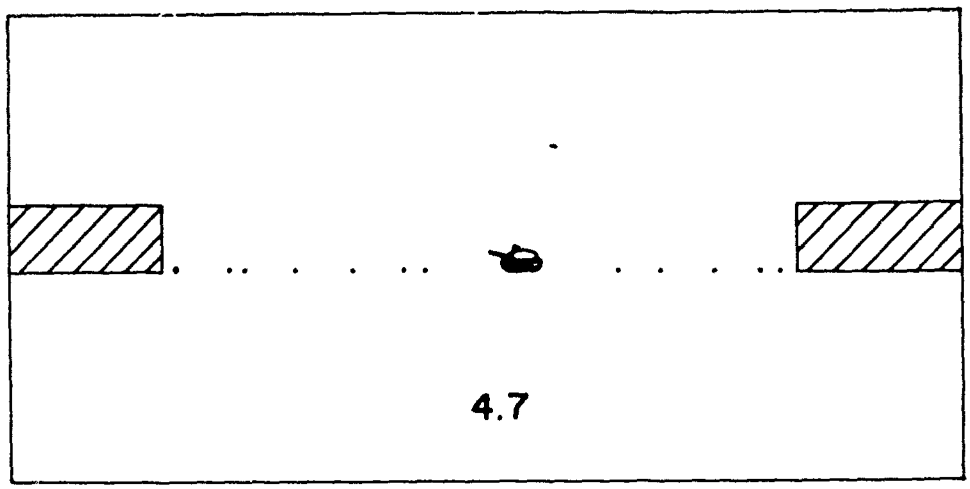


Figure 5. Gap program with target part way through a run.

The target was programmed to stop TF seconds after the subject fired. If the subject did not fire, the target disappeared into the covered area on one side of the gap. Thus, the subject could receive feedback about his performance in two ways, but only if he fired. If the target stopped in the open, the decision to fire was correct. If the target moved into the covered area without stopping, the decision to fire was wrong and analogous to wasting a missile.

Two seconds after a run was finished the display returned to the prompting mode similar to that shown in Figure 1. The gunner's decision whether or not to fire and the time at which he fired were recorded for each trial.

Procedure

In a pretest briefing, the subjects were shown the equipment and given detailed instructions on the operation of the display system and the techniques to determine if and when they should fire. They were advised to compare the target's position relative to the background (goal post, dot track, or concealed areas), count down TF while noting the relative distance the target moved, and to use all possible tricks to help them make their decision. Then, they watched an experimenter being tested in a series of mock trails on both the "shoot" and "gap" programs.

Subjects were tested individually on each of 5 days. Each day they were tested first on the Shoot program and about 1 hour later tested on the Gap program. Each test consisted of six practice runs and 24 data runs.

When undergoing testing, a subject sat alone in a low-light level soundproof room that housed the display CRT. An experimenter in another room viewed a CRT on which was displayed information identical to that shown the test subject. While one subject was being tested, the next subject viewed 10 of the tested subject's runs on the experimenter's CRT. After viewing the 10 test runs, the subject was asked by the experimenter if he had any questions regarding the test procedure. The subjects at this time appeared to comprehend the test procedures so there were very few questions. The subject was then told, "You will be given 30 target runs. The first six are for practice only and how well you do on the practice runs will not be recorded." The subject was then brought into the test room and the testing begun.

Each subject was tested on all 24 combinations of nominal values of test variables in each of the two programs. In the Shoot program, time to practice (TP), time to decide (TD), missile time of flight (TF), and target speed were varied within the limits described in Table 1C (Appendix C). In the Gap program, time of flight (TF), target speed, and re ,ap size were varied within the constraints shown in Table 2C (Appendix C).

In order for the first test subject to view his predecessor's performance, another experimenter acted as a test subject for 10 mock trials.

RESULTS

Data Reduction

For both programs, the computer recorded identifiers, target speed and target range for each run. For Shoot runs, TP and TD, and estimation error in mils (i.e., target position relative to the goal post at the end of TF) were also recorded. For Gap runs, the type of decision (fire or no-fire) and the time it took the subject to decide (if he fired), were recorded.

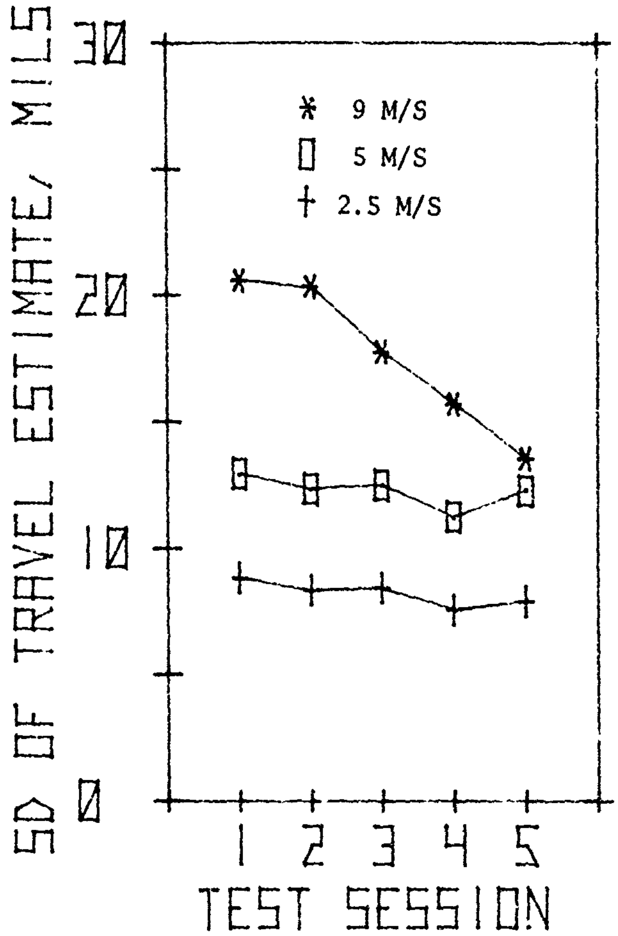
Only the nominal values of the independent variables (speed, gap size, etc.) were recorded. It should be remembered that the actual speed of the target (gap size, etc.) was chosen at random by the computer program within the constraints given in Appendix C. Thus, for a nominal target speed of 5 m/s the actual target speed could vary from 4 to 6 m/s.

At the end of each test day, summary statistics (means and SD's) were output on a communications terminal. Tables of the results are given in Appendix C (Shoot test) and Appendix D (Gap test).

Shoot Program

The Shoot program was designed to measure the subject's ability to estimate a target's future travel. By observing the target moving across the display, it was believed that the subject would estimate the target's relative speed and then, based on the displayed time of flight, determine when to fire so that the "missile" hit the target when the target center was at the goal post. It was assumed that the subject's performance in this task would improve with practice.

Figure 6 shows the relationship between the SD of the target position error (in mils) relative to the goal post (i.e., SD of gunner's errors) versus trial, as a function of speed. An examination of this figure shows some performance improvement with practice for the fastest target speed but almost constant performance over trials for the two slower speeds.

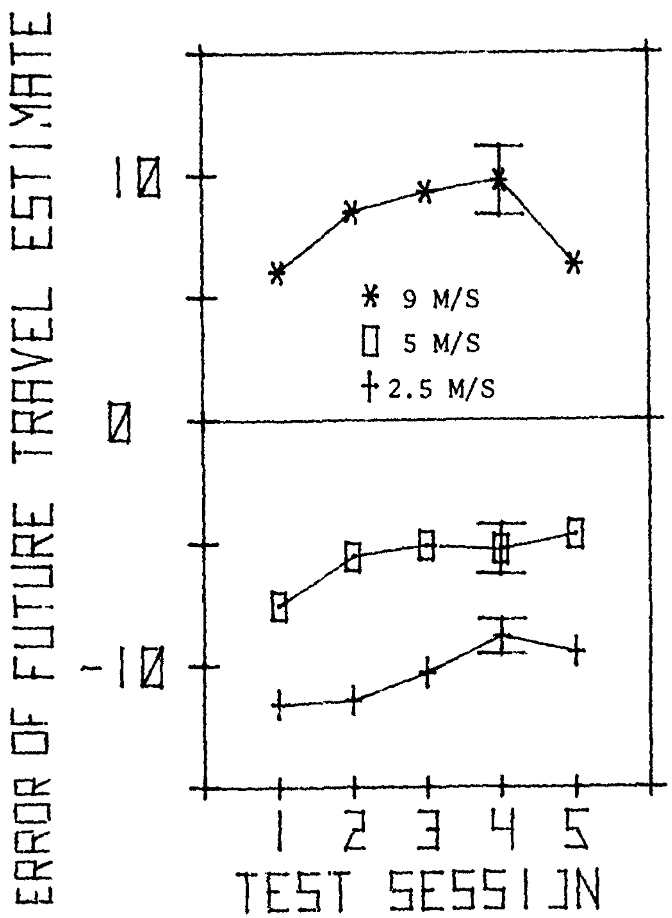


Note: Sample size for each point is 120.

Figure 6. SD of travel estimate as a function of target speed and practice.

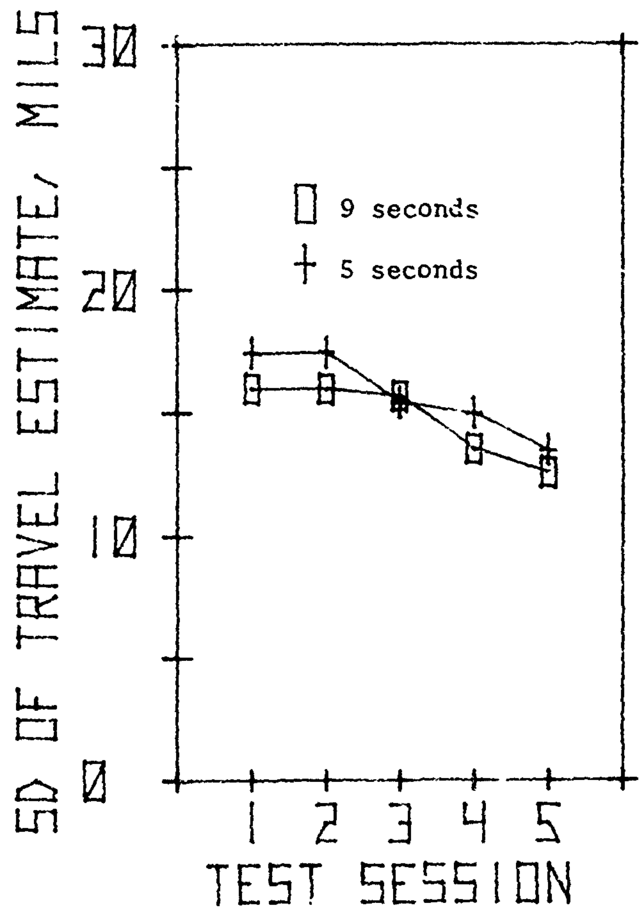
The mean error shown in Figure 7 tends to decrease with practice for the two slower speeds. At the slower speeds, the gunners tend to fire too early, whereas at the fastest speed, they fired late.

Relationships between gunner error and trial are shown as a function of time of flight (which is proportional to target range) in Figure 8. That performance increases with practice is quickly evident from this figure. Although a larger TF, 9 seconds, generally results in a more accurate estimate, the difference between results for a 9 seconds TF, and a 5 seconds TF is small, especially when compared to the effect of speed (Figure 6).



Note: Sample size for each point is 120. Symbols at session 4 indicate standard error of the mean.

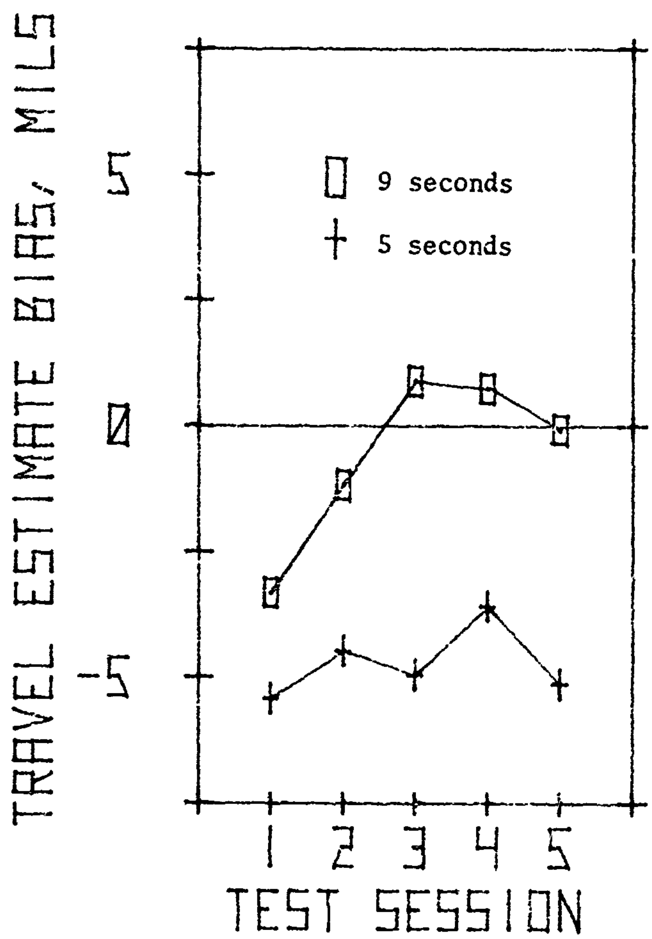
Figure 7. Mean error of future travel estimate as a function of target speed and practice.



Note: Sample size for each point is 180.

Figure 8. SD of travel estimate as a function of time of flight and practice.

Mean error versus trial shown in Figure 9 indicates relationships between TF and subject error similar to the ones shown for target speed in Figure 7, but of a smaller magnitude.

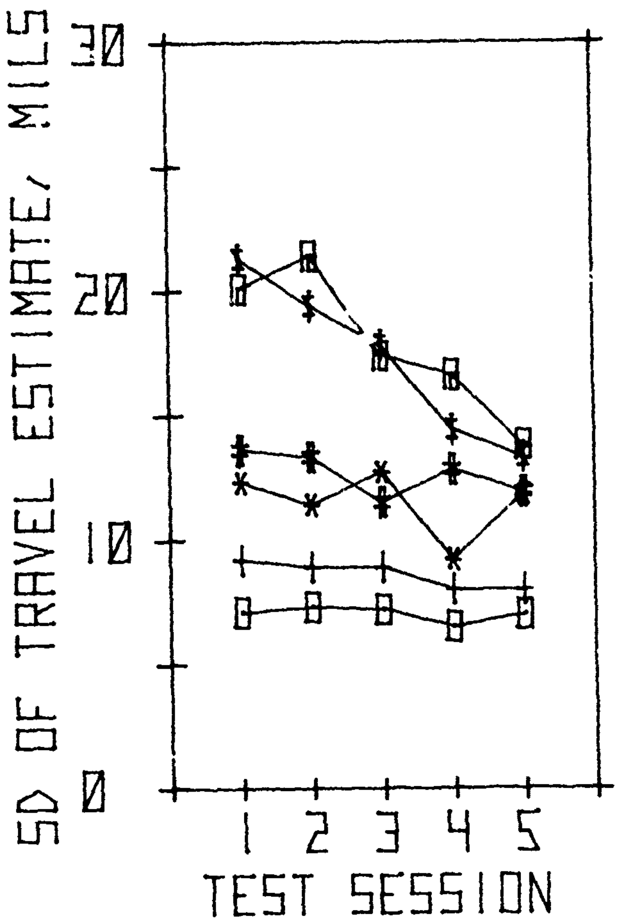


Note: Sample size for each point is 180.

Figure 9. Mean error of future travel estimate as a function of time of flight and practice.

The relationship between gunner error and target angular velocity (where angular velocity translates as a linear velocity on the display) is shown in Figures 10 and 11. From Figure 10, there is no apparent relationship between standard deviation and angular velocity; target speed has a greater influence. Also, in Figure 11 the relationship between mean error and target speed is stronger than that between angular velocity and mean error.

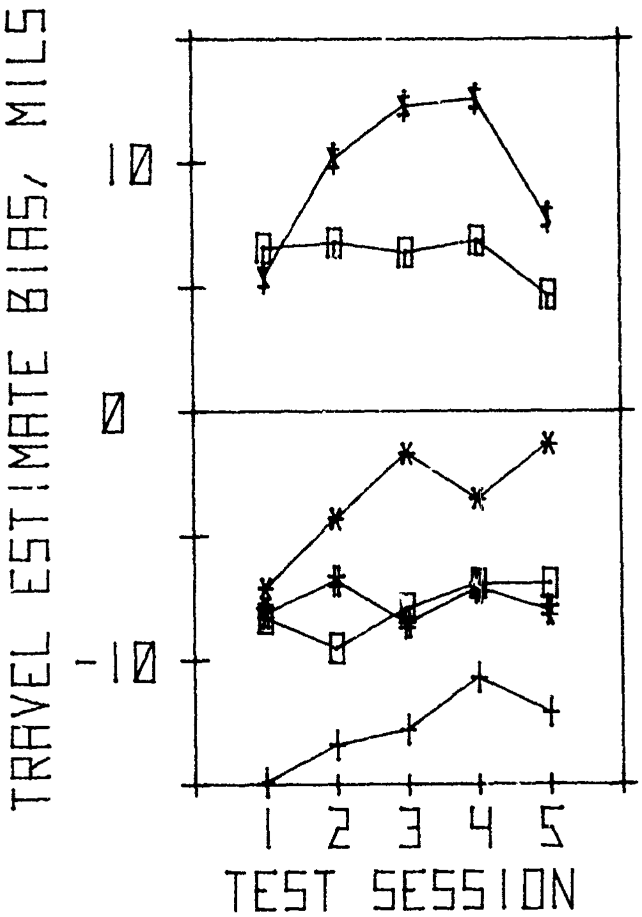
When subjects are required to estimate target speed in ordinary antitank weapon settings; e.g., with a 90mm recoilless rifle or an M72 LAW, the standard deviation of the estimate is often as high as 30 percent of the true value (5). Future travel estimates shown in Table 2 are of the same order of magnitude.



	Angular rate mrad/s	Speed m/s	TF s
+	5.0	2.5	5
□	2.8	2.5	9
*	5.6	5.0	9
‡	10.0	5.0	5
$	10.0	9.0	9
⊞	18.0	9.0	5.0

Note: Sample size for each point is 75.

Figure 10. SD of travel estimate as a function of angular rate and practice.



	Angular rate mrad/s	Speed m/s	TF s
+	5.0	2.5	5
□	2.8	2.5	9
✱	5.6	5.0	9
‡	10.0	5.0	5
⨦	10.0	9.0	9
◫	18.0	9.0	5.0

Note: Sample size for each point is 75.

Figure 11. Mean error of future travel estimate as a function of angular rate and practice.

TABLE 2

Future Travel Estimate as a Percentage of True Target Travel

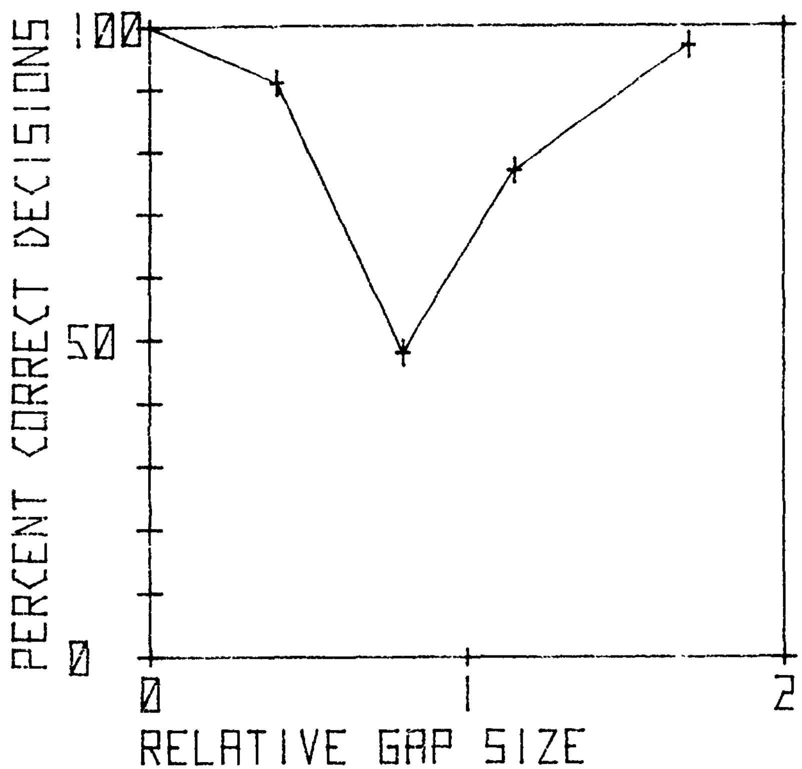
True Target Travel (mils)	TF (seconds)	Predicted travel as a percentage of true value: Mean	SD	RMS
25	5	-51	35	62
50	5	-15	25	29
90	5	7	20	21
25	9	-32	28	42
50	9	-7	23	24
90	9	-11	20	22
Combined	-	-15	33	37

Gap Program

The Gap Program was designed to measure the gunner's ability to decide whether or not to fire as a function of gap size for various target speeds and ranges. In the discussion that follows, we define gap size relative to the time of flight. For example, a unity gap size means that the linear measure of the gap size on the display is the same as the linear distance travelled by the target in the indicated time of flight. For a perfect gunner, the probability of firing would be zero for gap sizes less than unity, and would be one for gap sizes equal to or greater than unity.

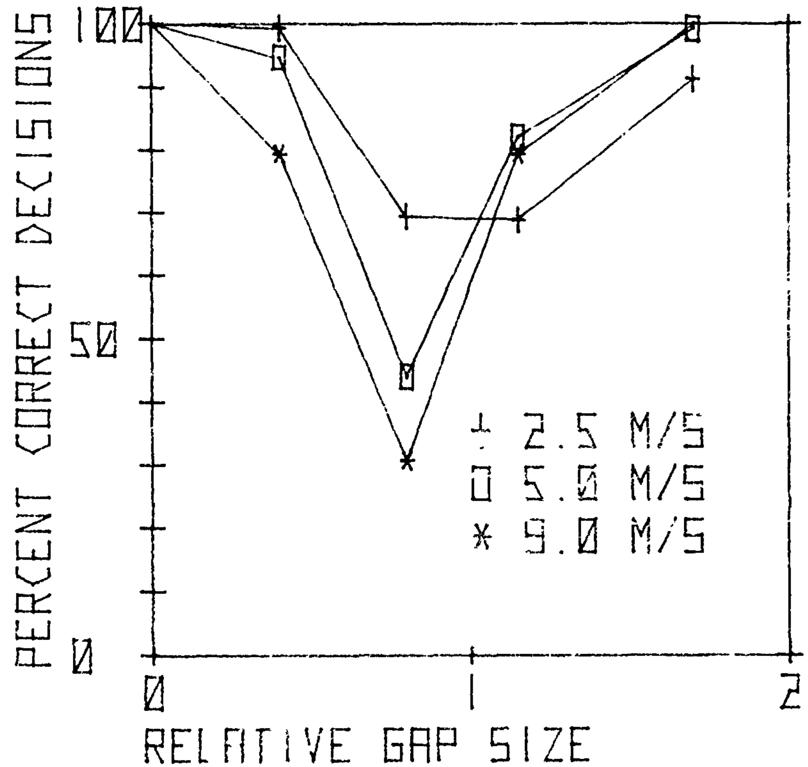
Figures 12 through 15 show probability of firing versus gap size for all conditions combined, and as a function of target speed, TF, and training, respectively. A number of relationships are evident from these figures. First, the relationship between gap size and correct decisions is strong (Figure 12). Second, there is an obvious influence of target speed on correct decisions (Figure 13). Third, decision making becomes more difficult as time of flight increases (Figure 14). Fourth, there is some positive effect of learning on correct decisions, especially for large gap sizes (Figure 15).

Figure 16 shows that there is little relationship between frequency of correct decisions and angular velocity. If there were a strong relationship the curves for a particular angular velocity would overlap and the curves for different angular velocities would be displaced from each other.



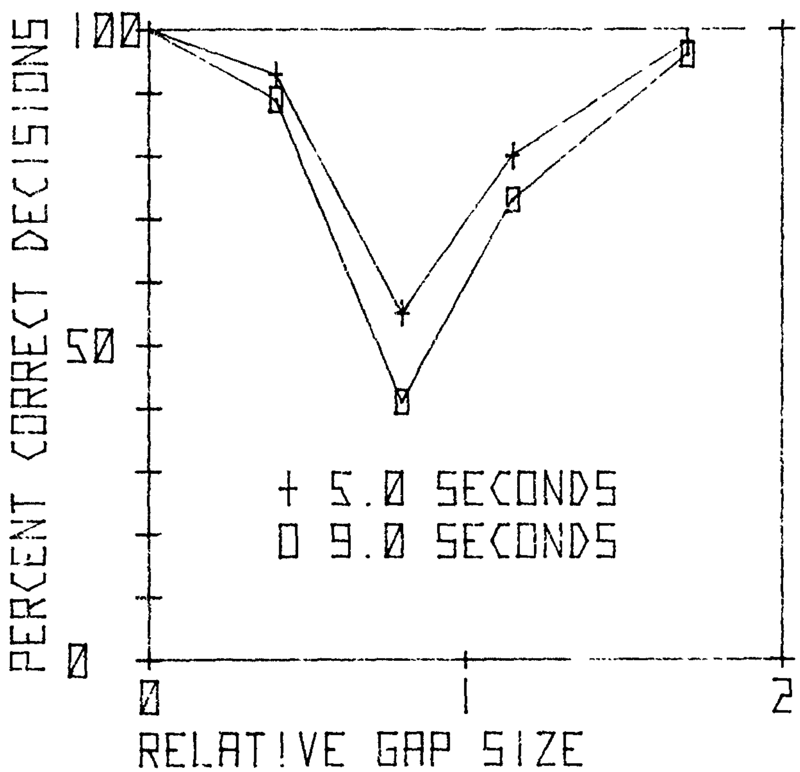
Note: Sample size for each point is 450.

Figure 12. Percent correct decisions as a function of relative gap size.



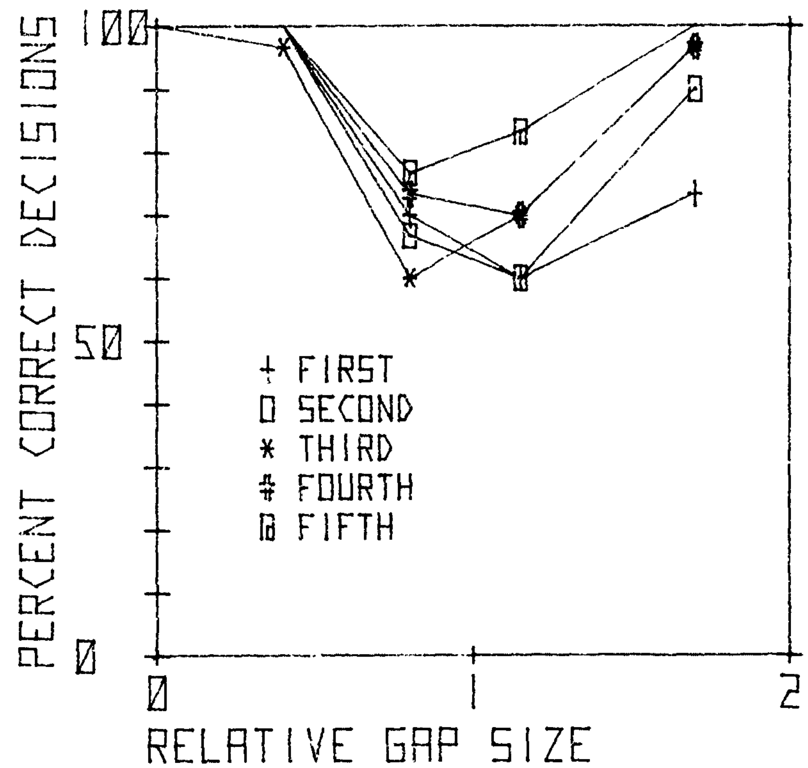
Note: Sample size for each point is 150.

Figure 13. Percent correct decisions as a function of target speed and relative gap size.



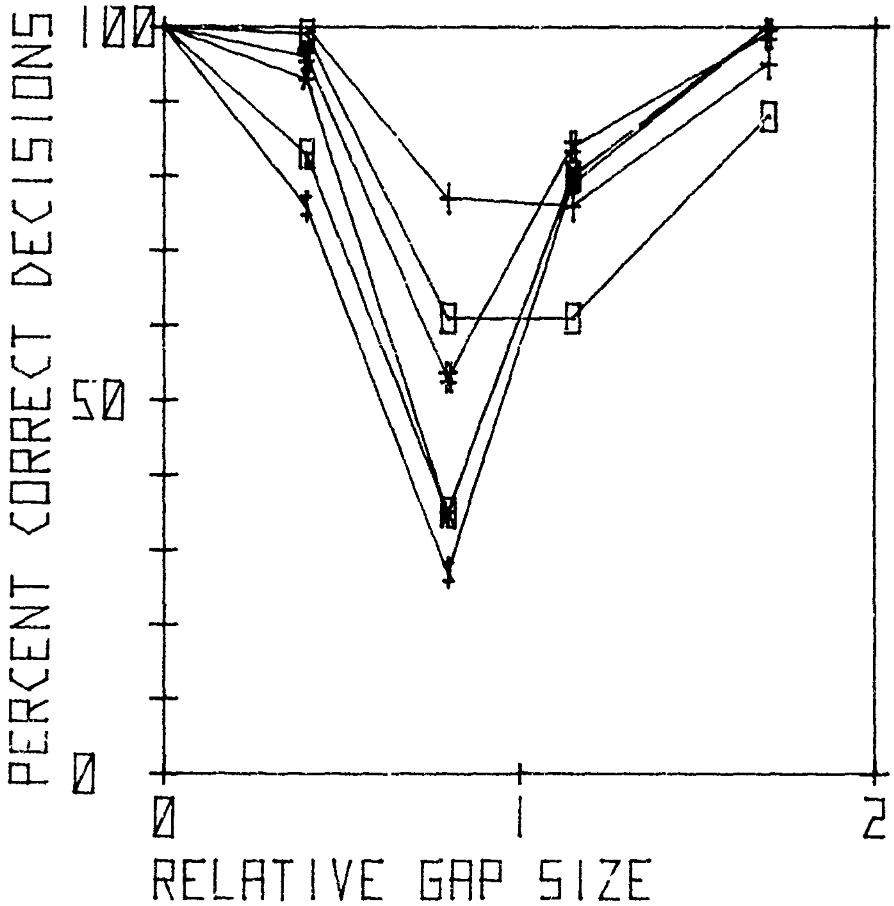
Note: Sample size for each point is 225.

Figure 14. Percent correct decisions as a function of time of flight and relative gap size.



Note: Sample size for each point is 120.

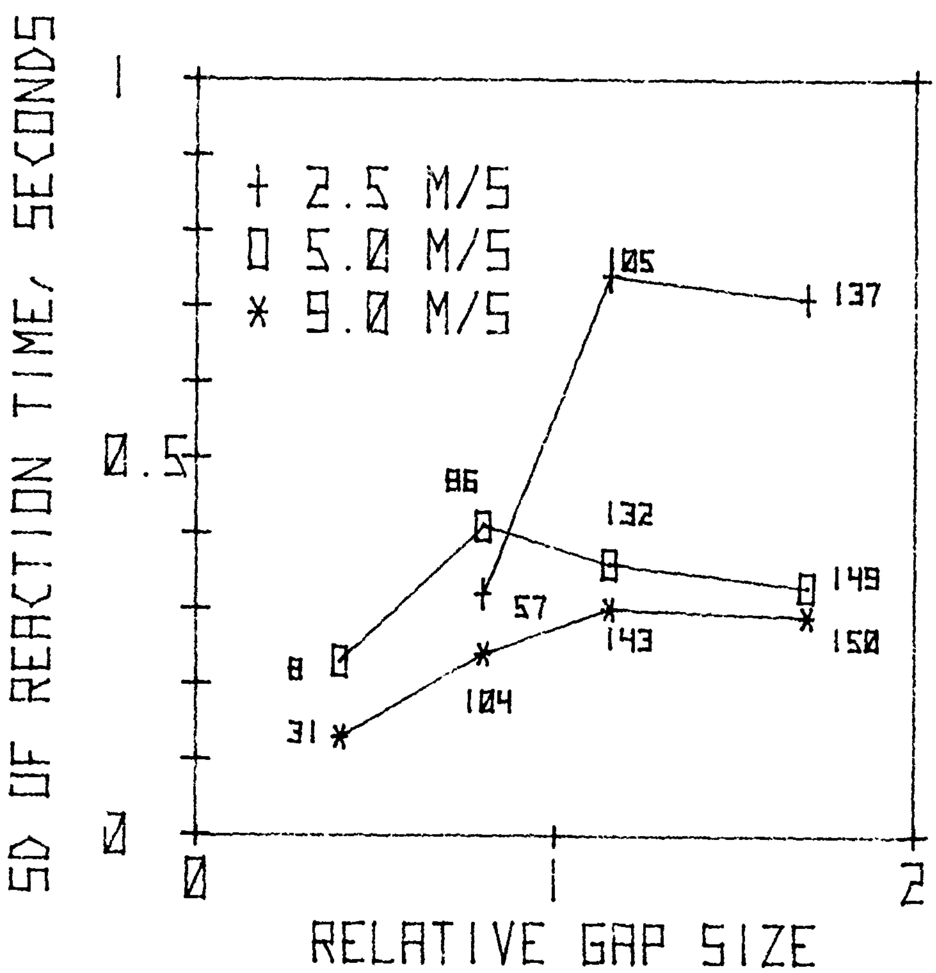
Figure 15. Percent correct decisions as a function of practice and relative gap size, for a target speed of 2.5 m/s.



	Angular rate mrad/s	Speed m/s	TF s
+	5.0	2.5	5
□	2.8	2.5	9
*	5.6	5.0	9
#	10.0	5.0	5
‡	10.0	9.0	9
⊡	18.0	9.0	5.0

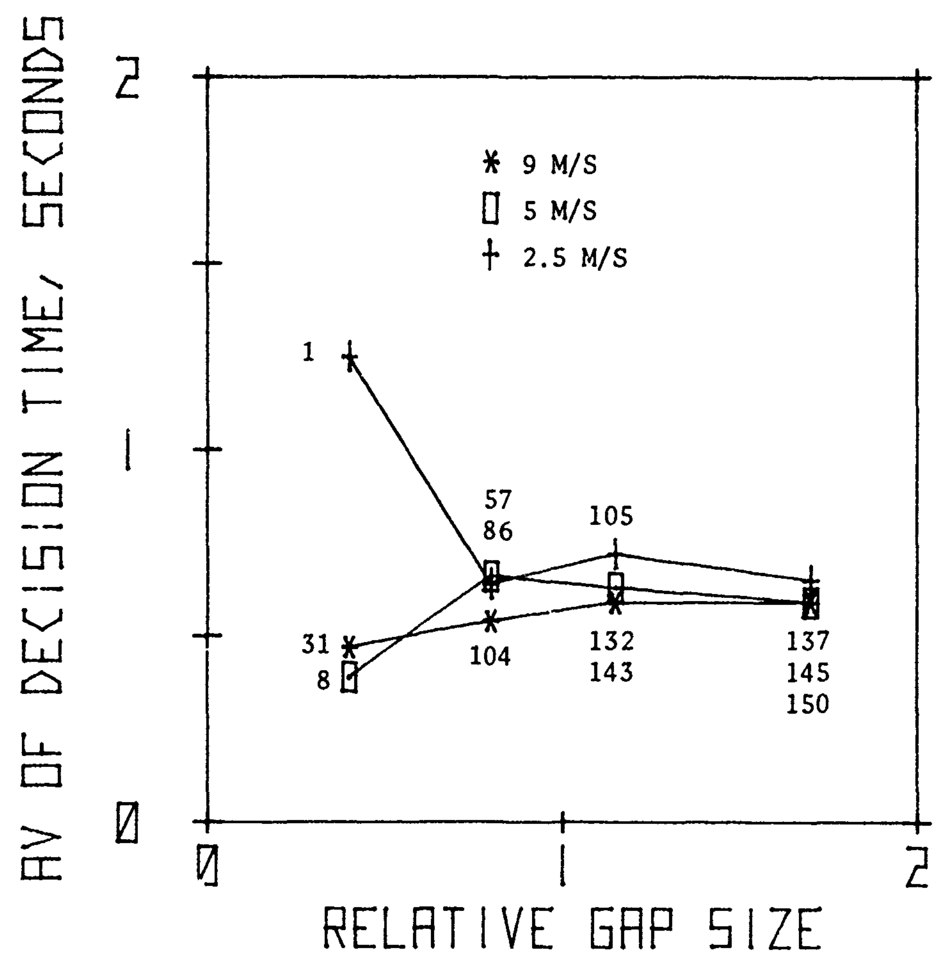
Figure 16. Percent correct decisions as a function of angular rate and relative gap size.

The time it took the subject to decide whether or not to fire is depicted in Figure 17 (SD) and Figure 18 (averages). Because decision time data could be recorded only if the subject fired, the indicated sample size increases with increasing gap size, and data for gap sizes less than unity represent incorrect decisions.



Note: Sample size for each point is indicated next to point.

Figure 17. SD of decision time as a function of target speed and relative gap size.



Note: Sample size shown next to each point.

Figure 18. Mean decision time measured with respect to appearance of the target center as a function of target speed and relative gap size.

Average decision time (Figure 18) is obviously independent of target speed (the deviant data point represents only one decision).

Figure 17 shows that the standard deviations do not differ substantially except for conditions of wide relative gaps. Since average reaction time is the same for all conditions, this indicates that while some gunners fire extremely early when presented slow targets, others are at first hesitant because the gap is small, but finally fire when they have assured themselves that the target is a slow one.

DISCUSSION

In both programs, a subject was required to estimate the target's future travel based on its perceived velocity and displayed time of flight. In the Shoot program, the gunner was given 2 or 10 seconds (TP) in which to estimate the target speed across the display. The objective was to determine when he should fire (i.e., a position with respect to the goal post), so that the target center and the goal post would be in line at the end of the missile time of flight. In this program the gunner always fired.

In the Gap program the gunner had to decide quickly whether or not to fire. This decision was based on his estimate of the distance the target would travel in TF seconds, relative to the gap size.

Even considering the difference between the two, it was believed that the results of the Shoot program would provide some insight regarding the results of the Gap program.

For a 2.5 m/s target travel estimate, errors in the Shoot program were approximately normally distributed with a mean of -10 mils and SD of 8 mils. This implies that the subjects overestimated target speed and fired too soon. In the Gap situation, if a target travelled at 2.5 m/s, the width of a unity gap would be 25 mils (Appendix B). Applying the "Shoot" data to this gap condition, future travel would still be overestimated with a mean of 35 mils and SD of 8 mils. Therefore, the subjects would be expected to fire about 10 percent of the time as illustrated in Figure 19, when in fact they fired about 70 percent of the time. This and comparisons for other target speeds are shown in Table 3.

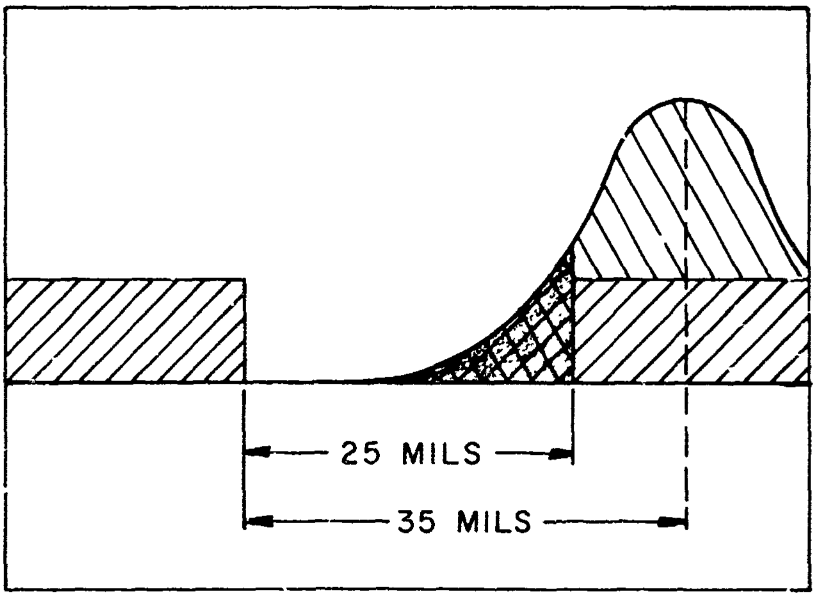


Figure 19. Distribution of future travel estimate with mean 35 mils superimposed on gap 25 mils wide.

TABLE 3

Comparison Between Synthetic and Real Decision Data

Unity Gap Size

Speed	Estimate, mils		Gap Size	Proportion of estimates that result in decision to fire	Real Firings
m/s	av	sd	mils	%	%
2.5	-10	8	25	11	70
5.0	-5	12	50	33	65
9.0	8	17	90	69	57

Obviously, this is not a fruitful way of comparing the two experiments.

In the Gap program, the limited time for the subjects to estimate target speed and future travel, and the fact that the subjects often fired before one-half of the target was exposed, leads to the conclusion that the subjects relied heavily if not completely on an intuitive estimate of target travel in deciding whether or not to fire.

If we view the results of the Shoot experiment as a valid measure of the gunner's ability to estimate speed and future target travel, we conclude that their abilities in this area are quite limited.

Because different sets of cues are obviously used by the subjects to make decisions in the two programs, there is probably not much to be gained from a replication of the Shoot situation in a field experiment. However, in a replication of the Gap situation, one would expect the general relationship between relative gap size and decision making ability to hold. Thus, relative gap sizes as small as 0.3 and relative gap sizes as large as 1.85 should result in almost 100 percent probability of making correct decisions, and relative gap sizes of approximately unity should make decision not much better than chance. It is to be remembered, however, that in the computer simulations time of flight information was explicitly available to the subjects in the form of a digital readout on the display. In a field experiment, where the subjects have to estimate distance using either range cards, memory, or plain eyesight, the decision making ability might not be as good.

Time required to make a decision is, of course, influenced by the situation. In a field experiment one would expect that decision making would take longer. For example:

1. If the subject is not sure of exactly where the target will appear;

2. If the subject has to start tracking in order to make his decision to fire count; or,

3. If the subject has to perform calculations to estimate range and/or time of flight.

Decision making ability should be expected to depend on target speed (Figure 13) and on practice (Figure 15). These facts should be accounted for in the design of future field experiments.

One parameter that was not varied in this experiment, but probably influences decision making, is the instruction given to the subjects. In this experiment we stressed the necessity of making correct decisions. This would imply that missing the opportunity to fire is just as bad as firing and wasting a missile. In a real situation that might not be true. If, for instance, the supply of missiles is for all practical purposes unlimited, and the risk of being detected by the enemy is small, it might be much worse to miss an opportunity to fire than to waste a missile. If, on the other hand, few missiles are available and the risk of being detected when firing is high, the gunner should fire only if he is extremely confident of doing so successfully. Thus, instructions elaborating on the missile supply situation, the risk of being detected when firing, enemy counterfire, etc., would probably influence the subjects willingness to fire.

One way of quantifying this could be to differentiate between scores for the four possible outcomes of a run, for example, as shown in Table 4.

TABLE 4

Payoff Matrix

		Correct Decision	
		Fire	No Fire
Subject's Decision	Fire	1	-2
	No Fire	-1	0

Varying the payoff matrix, and possibly rewarding subjects with high scores, should result in changes in the subject's behavior.

CONCLUSIONS

An ATGM gunner's ability to predict future target travel and to make a firing decision is generally limited.

The gunner's ability to estimate target future travel is comparable to his ability to estimate target speed in an ordinary antitank setting, where the SD of speed estimates is often as high as 25 to 30 percent of the true value.

Target speed and practice are the two variables that have the greatest influence on future travel estimation.

When it is essential to make a quick decision on whether or not to fire, future travel estimates are made using an intuitive approach rather than deliberation.

Target speed, practice, and the gap size influenced decision making most.

RECOMMENDATION

The results of this study should be used in planning a field study of ATGM gunners' ability to decide if a missile can be fired successfully.

In such an experiment, it will be important to vary target speed, gap size and range. In the more realistic setting of a field experiment, the implied consequences of various types of incorrect decisions and rewards for correct decisions may be of greater importance than in the simulation. Therefore, it is important that the payoff matrix be clearly defined.

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APPENDIX A

INFORMATION ON SUBJECTS

Subject Number	Service Time in Months	DRAGON Qualification Rating	Age in Years
1	24	Expert	20
2	8	Expert	19
3	33	1st Class Gunner	20
4	24	1st Class Gunner	20
5	18	Expert	20
6	20	1st Class Gunner	18
7	21	1st Class Gunner	19
8	20	Expert	20
9	36	-	27
10	17	-	19
11	32	Expert	23
12	18	Expert	20
13	38	1st Class Gunner	22
14	37	2d Class Gunner	37
15	47	Expert	21

APPENDIX B

TIME/SPACE FACTORS (INTERVISIBILITY)

Time/Space Factors
(Intervisibility)

According to Reference 1, Chapter 6, the width of a gap is calculated in meters. The gunner then assumes that target maximum speed is 22 mph (10 m/s) and calculates the distance a target can move during time of flight at the range in question. If this distance is less than the gap width, the gap is a "fire" zone, otherwise it is a "no-fire" zone.

However, time of flight (TF) increases almost linearly with range, (R).

To find the angle, A, that a target travels during time of flight:

$$A = \frac{\text{Distance Travelled}}{\text{Range}} \times 1000 \text{ mils} \tag{1}$$

Distance travelled is:

$$D = \text{Speed} \times \text{TF}, \tag{2}$$

Where TF is the time of flight.

The time of flight is approximately:

$$\text{TF} = \frac{\text{Range}}{100} \text{ seconds}, \tag{3}$$

because the missile velocity is about 100 meters/second.

Substituting $\frac{R}{100}$ for TF in (2) above we get

$$D = \text{Speed} \times \frac{\text{Range}}{100} \tag{4}$$

Substituting $\frac{\text{Speed} \times R}{100}$ for distance in (1) we get

$$A = \frac{\text{Speed} \times \text{Range} \times 1000}{100 \times \text{Range}} \tag{5}$$

Finally, using 10 m/s for target speed:

$$A = \frac{10 \times 1000}{100} = 100 \text{ mils} \tag{6}$$

That is, the angle travelled by the target during TF is constant for a given target speed. The same applies, of course, to all weapon systems where TF is reasonably linearly dependent on range. Thus, for TOW, the constant angle is 50 mils for a 10 m/s target.

The calculations above indicate that the method given in Reference 1 is unnecessarily complicated. A simplier method is to use some means of obtaining a 100 mil angle. One way is to use a binocular with a mil scale. Another is pointed out in Reference 1, Chapter 6, II f: The left and right limits of the optical sight indicate 100 meters at 1000 meters range, or 100 mils. A third way is to use three knuckles on the outstretched arm as a measure of approximately 100 mils.

For the TOW system which requires about 50 mils between covered areas (2), half of the optical sight field of view can be used to obtain the required angle.

APPENDIX C

PARAMETER COMBINATIONS IN SHOOT/GAP PROGRAMS

TABLE 1C

Parameter Combinations in Shoot Program

Time to[1] Practice (TP in Sec)	Time to[2] Decide (TD in sec)	Time of[3] Flight (TF in sec)	Target[4] Speed (meters/sec)	Mean Travel (mils)
2	3			
10	3	5.0		
2	9			
10	9		2.5	25
2	3			
10	3	9.0		
2	9			
10	9			
2	3			
10	3	5.0		
2	9			
10	9		5.0	50
2	3			
10	3			
2	9	9.0		
10	9			
2	3			
10	3	5.0		
2	9			
10	9		9.0	90
2	3			
10	3	9.0		
2	9			
10	9			

[1]T_P Values were constant.

[2]Computer picks T_D with equal probability within 3 ± 1.0 and 9.0 ± 1.0 seconds, respectively.

[3]Computer picks T_F with equal probability within 5.0 ± 1.0 and 9.0 ± 1.0 seconds, respectively.

[4]Computer picks target speed with equal probability within 2.5 ± .5, 5.0 ± 1, and 9 ± 1 seconds, respectively.

TABLE 2C

Parameter Combinations in Gap Program

Time of Flight, Sec[1] (TF in Sec)	Target Speed[2] (meters/sec)	Relative Gap Size[3] (TF/Distance)
5 9	2.5	
5 9	5.0	0.4
5 9	9.0	
5 9	2.5	
5 9	5.0	0.8
5 9	9.0	
5 9	2.5	
5 9	5.0	1.15
5 9	9.0	
5 9	2.5	
5 9	5.0	1.70
5 9	9.0	

[1]Computer picks T_F with equal probability within 5 ± 1 and 9 ± 1 seconds, respectively.

[2]Computer picks speed with equal probability within 2.5 ± 0.5, 5.0 ± 1.0, and 9.0 ± 1.0 m/s, respectively.

[3]Computer picks relative gap size within 0.4 ± 0.1, 0.8 ± 0.15, 1.15 ± 0.15, and 1.70 ± 0.20, respectively.

APPENDIX D

RESULTS OF SHOOT PROGRAM

TABLE 1D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for all Test Sessions

Parameter	N	AVG	SD
All	1800	-2.66	15.45
T_P 2.0	900	-1.30	15.93
10.0	900	-4.01	14.78
T_D 3.0 ± 1.0	900	2.31	12.90
9.0 ± 1.0	900	-7.62	16.19
T_F 5.0 ± 1.0	900	-4.73	15.78
9.0 ± 1.0	900	-0.59	14.85
SPD 2.5 ± 0.5	600	-10.34	8.25
5.0 ± 1.0	600	-5.62	12.28
9.0 ± 1.0	600	7.99	17.81

TABLE 2D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Test Session 1

Parameter	N	AVG	SD
All	360	-4.37	16.70
T_P 2.0	180	-3.10	16.78
10.0	180	-5.65	16.57
T_D 3.0	180	1.95	13.02
9.0	180	-10.69	17.59
T_F 5.0	180	-5.43	17.40
9.0	180	-3.32	15.96
SPD 2.5	120	-11.60	8.81
5.0	120	-7.55	12.95
9.0	120	6.03	20.59

TABLE 3D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Test Session 2

Parameter		N	AVG	SD
All		360	-2.84	16.76
T_P	2.0	180	-1.59	16.45
	10.0	180	-4.09	17.01
T_D	3.0	180	1.74	13.89
	9.0	180	-7.42	18.11
T_F	5.0	180	-4.49	17.42
	9.0	180	-1.18	15.94
SPD	2.5	120	-11.45	8.32
	5.0	120	-5.55	12.35
	9.0	120	8.49	20.34

TABLE 4D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Test Session 3

Parameter		N	AVG	SD
All		360	-2.04	15.78
T_P	2.0	180	-0.24	16.88
	10.0	180	-3.84	14.42
T_D	3.0	180	3.03	13.67
	9.0	180	-7.11	16.15
T_F	5.0	180	-4.96	15.39
	9.0	180	0.88	15.67
SPD	2.5	120	-10.32	8.41
	5.0	120	-5.11	12.50
	9.0	120	9.30	17.77

TABLE 5D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Test Session 4

Parameter		N	AVG	SD
All		360	-1.44	14.41
T_P	2.0	180	0.15	15.53
	10.0	180	-3.02	13.05
T_D	3.0	180	2.71	11.97
	9.0	180	-5.59	15.45
T_F	5.0	180	-3.61	14.97
	9.0	180	0.74	13.53
SPD	2.5	120	-8.83	7.55
	5.0	120	-5.25	11.24
	9.0	120	9.77	15.70

TABLE 6D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Test Session 5

Parameter		N	AVG	SD
All		360	-2.60	13.25
T_P	2.0	180	-1.74	14.13
	10.0	180	-3.47	12.28
T_D	3.0	180	2.10	11.90
	9.0	180	-7.31	12.88
T_F	5.0	180	-5.14	13.46
	9.0	180	-0.07	12.57
SPD	2.5	120	-9.48	7.88
	5.0	120	-4.66	12.28
	9.0	120	6.33	13.56

TABLE 7D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for All Sessions

Parameter		N	AVG	SD
TF	TP			
All	All	1800	-2.66	15.45
5 ± 1.0	2.5 ± .5	300	-12.77	8.66
	5.0 ± 1.0	300	-7.69	12.56
	9.0 ± 1.0	300	6.28	17.90
9 ± 1.0	2.5 ± .5	300	-7.01	7.04
	5.0 ± 1.0	300	-3.56	11.65
	9.0 ± 1.0	300	9.69	17.58

TABLE 8D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Session 1

Parameter		N	AVG	SD
Total		360	-4.37	16.70
TF	Speed			
5.0 ± 1.0	2.5 ± .5	60	-14.87	9.19
	5.0 ± 1.0	60	-8.05	13.64
	9.0 ± 1.0	60	6.64	20.05
9.0 ± 1.0	2.5 ± .5	60	-8.34	7.11
	5.0 ± 1.0	60	-7.05	12.32
	9.0 ± 1.0	60	5.43	21.28

TABLE 9D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Session 2

Parameter		N	AVG	SD
Total		360	-2.84	16.76
TF	Speed			
5.0 ± 1.0	2.5 ± .5	60	-13.40	8.89
	5.0 ± 1.0	60	-6.84	13.25
	9.0 ± 1.0	60	6.77	21.24
9.0 ± 1.0	2.5 ± 0.5	60	-9.49	7.27
	5.0 ± 1.0	60	-4.27	11.35
	9.0 ± 1.0	60	10.21	19.42

TABLE 10D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Session 3

Parameter		N	AVG	SD
Total		360	-2.04	15.78
TF	Speed			
5.0 ± 1.0	2.5 ± 0.5	60	-12.77	8.85
	5.0 ± 1.0	60	-8.48	11.48
	9.0 ± 1.0	60	6.36	17.42
9.0 ± 1.0	2.5 ± .5	60	-7.88	7.22
	5.0 ± 1.0	60	-1.74	12.67
	9.0 ± 1.0	60	12.25	17.77

TABLE 11D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Session 4

Parameter		N	AVG	SD
Total		360	-1.44	14.41
TF	Speed			
5.0 ± 1.0	2.5 ± .5	60	-10.73	8.06
	5.0 ± 1.0	60	-7.05	12.77
	9.0 ± 1.0	60	6.94	16.57
9.0 ± 1.0	2.5 ± 0.5	60	-6.94	6.54
	5.0 ± 1.0	60	-3.45	9.23
	9.0 ± 1.0	60	12.60	14.37

TABLE 12D

Shoot Results; Subject's Estimates (in Mils) of Target Travel for Session 5

Parameter		N	AVG	SD
Total		360	-2.60	13.25
TF	Speed			
5.0 ± 1.0	2.5 ± .5	60	-12.06	7.97
	5.0 ± 1.0	60	-8.04	11.89
	9.0 ± 1.0	60	4.69	13.75
9.0 ± 1.0	2.5 ± .5	60	-6.90	6.95
	5.0 ± 1.0	60	-1.29	11.83
	9.0 ± 1.0	60	7.97	13.27

APPENDIX E

RESULTS OF GAP PROGRAM

TABLE 1E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
All	All	All	% Right	91.1	48.0	76.7	96.9
			T AVG	0.07	-0.02	-0.02	-0.09
			T SD	0.21	0.44	0.56	0.58
			N	40	247	380	436
1	All	All	% Right	94.4	52.2	71.1	91.1
			T AVG	-0.01	0.06	0.12	0.01
			T SD	0.24	0.63	0.57	0.49
			N	5	45	75	82
2	All	All	% Right	90.0	45.6	75.6	96.7
			T AVG	0.11	-0.01	-0.06	-0.08
			T SD	0.12	0.36	0.52	0.47
			N	9	50	70	87
3	All	All	% Right	90.0	46.7	80.0	98.9
			T AVG	0.15	-0.10	0.00	-0.06
			T SD	0.12	0.37	0.74	0.85
			N	9	54	80	89
4	All	All	% Right	88.9	44.4	72.2	97.8
			T AVG	-0.01	-0.01	-0.06	-0.12
			T SD	0.31	0.38	0.47	0.51
			N	10	50	74	88
5	All	All	% Right	92.2	51.1	84.4	100.0
			T AVG	0.07	-0.00	-0.12	-0.17
			T SD	0.18	0.46	0.44	0.46
			N	7	48	81	90
All	5.0 $\pm$ 1.0	All	% Right	92.9	55.1	80.0	97.8
			T AVG	0.01	-0.10	-0.11	-0.20
			T SD	0.20	0.42	0.49	0.45
			N	16	113	194	220

TABLE 2E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
All	9.0 ± 1.0	All	% Right	89.3	40.9	73.3	96.0
			T AVG	0.10	0.05	0.07	0.03
			T SD	0.21	0.45	0.62	0.67
			N	24	134	186	216
1	5.0 ± 1.0	All	% Right	91.1	48.9	80.0	93.3
			T AVG	-0.03	0.01	-0.03	-0.09
			T SD	0.27	0.49	0.47	0.47
			N	4	24	39	42
1	9.0 ± 1.0	All	% Right	97.8	55.6	62.2	88.9
			T AVG	0.05	0.12	0.29	0.12
			T SD	0.0	0.78	0.62	0.49
			N	1	20	36	40
2	5.0 ± 1.0	All	% Right	95.6	55.6	80.0	97.8
			T AVG	-0.03	-0.09	-0.08	-0.21
			T SD	0.04	0.35	0.59	0.39
			N	2	21	37	44
2	9.0 ± 1.0	All	% Right	84.4	35.6	71.1	95.6
			T AVG	0.15	0.04	-0.03	0.05
			T SD	0.11	0.36	0.44	0.52
			N	7	29	33	43
3	5.0 ± 1.0	All	% Right	95.6	57.8	80.0	100.0
			T AVG	0.15	-0.14	-0.09	-0.18
			T SD	0.07	0.38	0.44	0.49
			N	2	24	40	45
3	9.0 ± 1.0	All	% Right	84.4	35.6	80.0	97.8
			T AVG	0.15	-0.07	0.10	0.07
			T SD	0.14	0.37	0.95	1.09
			N	7	30	40	44

TABLE 3E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
4	5.0 ± 1.0	All	% Right	86.7	53.3	75.6	97.8
			T AVG	-0.02	-0.15	-0.12	-0.23
			T SD	0.24	0.32	0.52	0.46
			N	6	21	39	44
4	9.0 ± 1.0	All	% Right	91.1	35.6	68.9	97.8
			T AVG	0.00	0.08	0.00	-0.00
			T SD	0.43	0.39	0.42	0.54
			N	4	29	35	44
5	5.0 ± 1.0	All	% Right	95.6	60.0	84.4	100.0
			T AVG	0.08	-0.14	-0.22	-0.27
			T SD	0.04	0.54	0.44	0.41
			N	2	22	39	45
5	9.0 ± 1.0	All	% Right	88.9	42.2	84.4	100.0
			T AVG	0.07	0.11	-0.03	-0.06
			T SD	0.23	0.34	0.42	0.49
			N	5	26	42	45
All	All	2.5 ± .5	% Right	99.3	69.3	68.7	91.3
			T AVG	0.05	-0.56	-0.48	-0.55
			T SD	-	0.32	0.74	0.71
			N	1	57	105	137
All	All	5.0 ± 1.0	% Right	94.7	44.0	82.0	99.3
			T AVG	-0.21	0.06	0.03	-0.01
			T SD	0.23	0.41	0.36	0.33
			N	8	86	132	149
All	All	9.0 ± 1.0	% Right	79.3	30.7	79.3	100.0
			T AVG	0.14	0.21	0.26	0.26
			T SD	0.13	0.24	0.30	0.29
			N	31	104	143	150

TABLE 4E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
1	All	2.5 ± .5	% Right	-	70.0	60.0	73.3
			T AVG	-	-0.66	-0.16	-0.50
			T SD	-	0.34	0.84	0.39
			N	0	11	20	22
1	All	5.0± 1.0	% Right	96.7	43.3	76.7	100.0
			T AVG	-0.40	0.34	0.07	0.04
			T SD	-	0.69	0.32	0.38
			N	1	17	26	30
1	All	9.0 ± 1.0	% Right	86.7	43.3	76.7	100.0
			T AVG	0.09	0.25	0.36	0.35
			T SD	0.11	0.26	0.39	0.30
			N	4	17	29	30
2	All	2.5 ± .5	% Right	-	66.7	60.0	90.0
			T AVG	-	-0.51	-0.69	-0.55
			T SD	-	0.19	0.28	0.46
			N	0	11	17	27
2	All	5.0 ± 1.0	% Right	93.3	46.7	73.3	100.0
			T AVG	0.03	0.02	0.08	0.03
			T SD	0.04	0.25	0.57	0.37
			N	2	16	23	30
2	All	9.0 ± 1.0	% Right	76.7	23.3	93.3	100.0
			T AVG	0.14	0.20	0.20	0.22
			T SD	0.13	0.23	0.22	0.19
			N	7	23	30	30
3	All	2.5 ± .5	% Right	96.7	60.0	70.0	96.7
			T AVG	0.05	-0.51	-0.34	-0.44
			T SD	-	0.30	1.25	1.36
			N	1	16	22	29

TABLE 5E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
3	All	5.0 ± 1.0	% Right	-	50.0	93.3	100.0
			T AVG	-	-0.03	0.03	0.02
			T SD	-	0.31	0.39	0.35
			N	0	17	30	30
3	All	9.0 ± 1.0	% Right	73.3	30.0	76.7	100.0
			T AVG	0.16	0.15	0.26	0.23
			T SD	0.12	0.14	0.28	0.23
			N	8	21	28	30
4	All	2.5 ± .5	% Right	-	73.3	70.0	96.7
			T AVG	-	-0.54	-0.58	-0.58
			T SD	-	0.37	0.40	0.43
			N	0	8	21	29
4	All	5.0 ± 1.0	% Right	90.0	33.3	76.7	96.7
			T AVG	-0.37	-0.00	-0.01	-0.05
			T SD	0.18	0.30	0.22	0.26
			N	3	20	24	29
4	All	9.0 ± 1.0	% Right	76.7	26.7	70.0	100.0
			T AVG	0.14	0.17	0.27	0.27
			T SD	0.20	0.24	0.33	0.41
			N	7	22	29	30
5	All	2.5 ± .5	% Right	-	76.7	83.3	100.0
			T AVG	-	-0.57	-0.62	-0.65
			T SD	-	0.41	0.30	0.30
			N	0	11	25	30
5	All	5.0 ± 1.0	% Right	93.3	46.7	90.0	100.0
			T AVG	-0.13	-0.01	0.01	-0.07
			T SD	0.25	0.21	0.27	0.28
			N	2	16	29	30

TABLE 6E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
5	All	9.0 ± 1.0	% Right	83.3	30.0	80.0	100.0
			T AVG	0.15	0.30	0.21	0.21
			T SD	0.09	0.31	0.25	0.28
			N	5	21	27	30
All	5.0 ± 1.0	2.5 ± .5	% Right	100.0	77.3	76.0	94.7
			T AVG	0.00	-0.65	-0.60	-0.70
			T SD	0.00	0.29	0.42	0.29
			N	0	27	57	71
All	5.0 ± 1.0	5.0 ± 1.0	% Right	96.0	53.3	84.0	98.7
			T AVG	-0.32	-0.05	-0.03	-0.11
			T SD	0.10	0.28	0.40	0.24
			N	3	37	66	74
All	5.0 ± 1.0	9.0 ± 1.0	% Right	82.7	34.7	80.0	100.0
			T AVG	0.09	0.17	0.21	0.19
			T SD	0.11	0.27	0.26	0.22
			N	13	49	71	75
All	9.0 ± 1.0	2.5 ± .5	% Right	98.7	61.3	61.3	88.0
			T AVG	0.05	-0.47	-0.33	-0.38
			T SD	0.0	0.33	0.98	0.95
			N	1	30	48	66
All	9.0 ± 1.0	5.0 ± 1.0	% Right	93.3	34.7	80.0	100.0
			T AVG	-0.15	0.15	0.10	0.10
			T SD	0.27	0.47	0.32	0.38
			N	5	49	66	75
All	9.0 ± 1.0	9.0 ± 1.0	% Right	76.0	26.7	78.7	100.0
			T AVG	0.18	0.25	0.31	0.32
			T SD	0.14	0.22	0.33	0.34
			N	18	55	72	75

TABLE 7E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
1	5.0	2.5	% Right	100.0	80.0	66.7	80.0
			T AVG	0.0	-0.74	-0.43	-0.64
			T SD	0.0	0.41	0.65	0.23
			N	0	5	11	12
1	5.0	5.0	% Right	93.3	46.7	86.7	100.0
			T AVG	-0.40	0.15	-0.00	-0.06
			T SD	0.0	0.32	0.28	0.30
			N	1	8	13	15
1	5.0	9.0	% Right	80.0	20.0	86.7	100.0
			T AVG	0.10	0.23	0.23	0.30
			T SD	0.13	0.27	0.15	0.31
			N	3	12	15	15
1	9.0	2.5	% Right	100.0	60.0	53.3	66.7
			T AVG	0.0	-0.59	0.18	-0.34
			T SD	0.0	0.29	0.96	0.48
			N	0	6	9	10
1	9.0	5.0	% Right	100.0	40.0	66.7	100.0
			T AVG	0.0	0.50	0.15	0.14
			T SD	0.0	0.89	0.36	0.44
			N	0	9	13	15
1	9.0	9.0	% Right	93.3	66.7	66.7	100.0
			T AVG	0.05	0.22	0.50	0.39
			T SD	0.0	0.26	0.52	0.29
			N	1	5	14	15
2	5.0	2.5	% Right	100.0	73.3	73.3	93.3
			T AVG	0.0	-0.56	-0.67	-0.66
			T SD	0.0	0.22	0.36	0.25
			N	0	5	10	14

TABLE 8E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
2	5.0	5.0	% Right	100.0	60.0	73.3	100.0
			T AVG	0.0	-0.03	0.12	-0.16
			T SD	0.0	0.23	0.75	0.18
			N	0	6	12	15
2	5.0	9.0	% Right	86.7	33.3	93.3	100.0
			T AVG	-0.03	0.12	0.15	0.15
			T SD	0.04	0.22	0.21	0.17
			N	2	10	15	15
2	9.0	2.5	% Right	100.0	60.0	46.7	86.7
			T AVG	0.0	-0.48	-0.74	-0.43
			T SD	0.0	0.18	0.10	0.60
			N	0	6	7	13
2	9.0	5.0	% Right	86.7	33.3	73.3	100.0
			T AVG	0.03	0.05	0.04	0.23
			T SD	0.04	0.27	0.28	0.41
			N	2	10	11	15
2	9.0	9.0	% Right	66.7	13.3	93.3	100.0
			T AVG	0.20	0.27	0.25	0.29
			T SD	0.08	0.22	0.22	0.18
			N	5	13	15	15
3	5.0	2.5	% Right	100.0	80.0	73.3	100.0
			T AVG	0.0	-0.57	-0.58	-0.74
			T SD	0.0	0.33	0.24	0.35
			N	0	6	11	15
3	5.0	5.0	% Right	100.0	60.0	86.7	100.0
			T AVG	0.0	-0.14	-0.07	-0.02
			T SD	0.0	0.36	0.32	0.29
			N	0	8	15	15

TABLE 9E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
3	5.0	9.0	% Right	86.7	33.3	80.0	100.0
			T AVG	0.15	0.12	0.27	0.21
			T SD	0.07	0.14	0.27	0.16
			N	2	10	14	15
3	9.0	2.5	% Right	93.3	40.0	66.7	93.3
			T AVG	0.05	-0.47	-0.10	-0.11
			T SD	0.0	0.29	1.76	1.90
			N	1	10	11	14
3	9.0	5.0	% Right	100.0	40.0	100.0	100.0
			T AVG	0.0	0.07	0.12	0.05
			T SD	0.0	0.24	0.43	0.40
			N	0	9	15	15
3	9.0	9.0	% Right	60.0	26.7	73.3	100.0
			T AVG	0.17	0.19	0.25	0.25
			T SD	0.14	0.15	0.30	0.29
			N	6	11	14	15
4	5.0	2.5	% Right	100.0	73.3	80.0	100.0
			T AVG	0.0	-0.64	-0.60	-0.71
			T SD	0.0	0.20	0.48	0.37
			N	0	4	12	15
4	5.0	5.0	% Right	86.7	40.0	80.0	93.3
			T AVG	-0.22	-0.12	-0.10	-0.15
			T SD	0.11	0.23	0.21	0.17
			N	2	9	12	14
4	5.0	9.0	% Right	73.3	46.7	66.7	100.0
			T AVG	0.11	0.07	0.25	0.19
			T SD	0.16	0.15	0.41	0.20
			N	4	8	15	15

TABLE 10E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
4	9.0	2.5	% Right	100.0	73.3	60.0	93.3
			T AVG	0.0	-0.45	-0.56	-0.44
			T SD	0.0	0.50	0.29	0.45
			N	0	4	9	14
4	9.0	5.0	% Right	93.3	26.7	73.3	100.0
			T AVG	-0.55	0.09	0.08	0.04
			T SD	0.0	0.33	0.20	0.30
			N	1	11	12	15
4	9.0	9.0	% Right	80.0	6.7	73.3	100.0
			T AVG	0.18	0.23	0.29	0.35
			T SD	0.28	0.27	0.24	0.55
			N	3	14	14	15
5	5.0	2.5	% Right	100.0	80.0	86.7	100.0
			T AVG	0.00	-0.71	-0.70	-0.74
			T SD	0.00	0.29	0.31	0.22
			N	0	7	13	15
5	5.0	5.0	% Right	100.0	60.0	93.3	100.0
			T AVG	0.00	-0.11	-0.07	-0.18
			T SD	0.00	0.12	0.24	0.19
			N	0	6	14	15
5	5.0	9.0	% Right	86.7	40.0	73.3	100.0
			T AVG	0.08	0.29	0.14	0.10
			T SD	0.04	0.43	0.21	0.22
			N	2	9	12	15
5	9.0	2.5	% Right	100.0	73.3	80.0	100.0
			T AVG	0.00	-0.33	-0.53	-0.56
			T SD	0.00	0.52	0.27	0.35
			N	0	4	12	15

TABLE 11E

Gap Program Results

Test Session	TF (Sec)	SPD (m/sec)		Gap Size 0.4	0.8	1.15	1.70
5	9.0	5.0	% Right	86.7	33.3	86.7	100.0
			T AVG	-0.13	0.06	0.08	0.04
			T SD	0.25	0.23	0.28	0.32
			N	2	10	15	15
5	9.0	9.0	% Right	80.0	20.0	86.7	100.0
			T AVG	0.20	0.30	0.26	0.33
			T SD	0.09	0.21	0.27	0.29
			N	3	12	15	15
			% Right				
			T AVG				
			T SD				
			N				
			% Right				
			T AVG				
			T SD				
			N				
			% Right				
			T AVG				
			T SD				
			N				
			% Right				
			T AVG				
			T SD				
			N				
			% Right				
			T AVG				
			T SD				
			N				